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SOME VEGETABLES GROWN IN THE PHILIPPINE ISLANDS[1]

By FRANCISCO AGCAOILI

(From the Laboratory of Organic Chemistry, Bureau of Science, Manila, P. I.)

The question of food and food supply is a matter that early concerns the minds of a people no matter how primitive they may be, and the degree to which they have solved this problem is a fair measure of the stage of civilization at which they have arrived. When a majority of the inhabitants of a country is necessarily employed in the cultivation of nurture crops, no high state of civilization has been attained nor is it possible to attain such a state until a radical change has been made in the food supply of that country.

This is not meant to imply that food alone controls the civilization of a country, for one can readily conceive of a state enjoying the greatest supply of food with the least necessary effort in the obtaining of this supply and yet falling far short of being a highly civilized community. But the converse is more nearly always true, that a nation must have leisure from the harrowing toil in the field for mere existence, in order that other fields of labor may be developed and that individuals may have time to cultivate the graces of the mind and body. Consequently the preparation of some fairly concentrated food is needed to bring about this condition—the condition where man need not devote a large proportion of his time to the merely routine task of preparing and taking nourishment.

However, this is but one phase of the result of eating an ill-

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[1] Received for publication December 15, 1915.

nourishing food. Other important results are the undersized body and low vitality. These conditions react one on the other, making it more difficult for the weakling to obtain his food and complicating the effect still further.

Therefore I contend that to raise a nation in the scale of civilization her food supply and the preparation of her food supply should receive early consideration.

Experts in nutrition claim that man instinctively attempts to obtain a complete diet and point out that such combinations as mush and milk; maize porridge (*polenta*) and cheese; corn and beans; rice, fish, and fat; potatoes and meat; and analogous combinations are well-known examples of this instinctive desire to consume a well-balanced diet. But the gratification of such a desire necessitates the cultivation of these foods.

Recently I have had occasion to determine the nutritive value of a number of the vegetables indigenous to the Philippine Islands and imported here, which are used for food by the people. A brief description of the methods of preparation and a table of nutritive values follow:

Eggplant.—Solanum melongena L., *berengena* (Sp.),[2] *tarong* (Il.), *talong* (T., V.), *balasenas* (Pam.). The eggplant is very plentiful in the markets at all times owing to the ease with which it can be grown. It is prepared for food by boiling and seasoning.

Squash.—Cucurbita maxima Duchesne, *calabaza* (Sp., V.), *carabasa* (Il.), *calabasang bilog* (T.), *culubasa* (Pam.). The squash grows best during the dry season under irrigation. The fruit is eaten green or ripe, and the leaves and flowers are stewed.

Cowpea.—Vigna sesquipedalis L., *sitao* (Il., T.), *hamtac* (V.), *camangian* (Pam.). The unripe pods and the ripe seeds and leaves are used for food. They should eventually find a place as a forage crop and as an excellent crop to use for the improvement of the soil, since they grow well here. A peculiar dish is made from the sprouted seeds of the cowpea. It is known as *tógue* in the Manila market.

Bottle gourd.—Lagenaria leucantha (Lam.) Rusby, *calabasa blanca* (Sp.), *tabuñgao* (Il.), *upo* (T., Pam.), *sicay calubay* (V.). The green fruit is used like the squash. Another variety, the sponge gourd (*Luffa cylindrica* Roem.), *patola* (Sp., T., V., Pam.), *cabatiti* (Il.), is used in soups and in stews when unripe.

Wax gourd.—Benincasa cerifera Savi, *condol* (T., Pam.), *tan-*

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[2] Letters in parentheses indicate the source of the local names: Il., Ilocano; Pam., Pampanga; Sp., Spanish; T., Tagalog; V., Visayan.

cuy (Il.). The wax gourd is a beautiful fruit, being similar in outward appearance to a watermelon. The meat is made into preserve or cooked like the squash.

Horse-radish tree.—Moringa oleifera Lam., *marungay* (Il.), V.), *malungay* (T.). The fruit and young leaves are boiled and eaten.

Chick-pea.—Cicer arietinum L., *garbanzos* (Sp., Il., T., V., Pam.). Extensively imported from Spain and used for food in most parts of the Philippines.

Common bean, habichuelas.—Many varieties of beans are grown in the Philippine Islands and their value as an article of diet is becoming more and more appreciated. Most of them are consumed when green.

Tomato.—Tomate (Sp.), *camatis* (Il., T., V., Pam.). Tomatoes can usually be obtained in the market. During the rainy season, however, they are somewhat scarce, so that the relative cost is high. A favorite dish is a mixture of rice, fish, and tomatoes.

Breadfruit.—Artocarpus communis Linn., *rima* (Sp.), *pacac* (Il.), *camansi* (T., V., Pam.). The seedless breadfruit may be roasted or used to make preserves. The seeded fruit is often boiled with squash and meat. However, breadfruit is not plentiful, and it is not a very common article of diet.

Batao.—Dolichos lablab L., *batao* (Sp., T.), *parda* (Il.). Batao is very similar to the bean in appearance. Only the young pods are eaten.

Papaya.—Carica papaya L., *papaya* (Sp., Il., T., V., Pam.). Papayas grow in the cultivated and wild state in the Philippine Islands and can be obtained in quantities, except during a part of the rainy season. Those introduced from the Hawaiian Islands are the finest. The ripe ones are eaten raw with salt or lemon, or both, or as a salad, while the green ones are cooked for sauce and with meat. They have the property of making meat more tender, due to the presence of the proteolytic ferment, papain.

Cucumber.—Cucumis sativus L., *pepino* (Sp., Il., T., V., Pam.). The cucumber grows very readily in the vicinity of Manila, although it cannot always be purchased in the market. This is probably due to the need for cultivation and care in its growth. Gardening has not reached a high degree of development; consequently vegetables requiring attention are not plentiful.

Amargoso.—Momordica charantia L., *amargoso* (Sp.), *paria* (Il.), *ampalaya* (T.), *sampalla* (V.), *apalia* (Pam.). *Amargoso* is a Spanish word for "bitter," a property of this fruit. It grows both wild and in the cultivated state. The green fruits are sliced and cooked in salted water to reduce the bitterness and are then eaten with meat as a relish. The fruits are also pickled. The leaves and flowers are also cooked and eaten.

Cangcong.—Ipomoea reptans Poir, *balangeg* (Il.), *cangcong* (T.), *tangcong* (V.), *cancong* (Pam.). This plant resembles the sweet potato vine and belongs in the same genus. It is commonly used as a pot herb. It is very plentiful.

Pepper.—Capsicum annum L., *pimento* (Sp.), *silit sairo* (Il.), *sili* (T.), *lara* (Pam.). Not only the fruit of the pepper, but also the leaves are used in the various foods for seasoning and condimental purposes.

Sweet potato.—Ipomoea batatas (L.) Poir, *camote* (Sp., T., Pam.), *camutig* (Il.), *tigsi* (V.). The sweet potato is becoming much more common, and as it grows luxuriantly, is of fine quality, and is much more palatable than the yam, it will eventually largely displace the latter as it has done in the United States. The Irish potato can be grown only at higher altitudes, and consequently it would appear that the sweet potato should become a staple crop for consumption. Because of the simple culinary devices of the people, most of the potatoes are baked. This is fortunate, as dietitians agree that the most economical and digestible method of preparing potatoes is by roasting.

Yam.—Dioscorea spp., *ube* (Sp., T., V., Pam.), (*D. alata* L.). The yam can always be bought in the markets at a very low price. It is prepared for eating in the same way as the sweet potato.

Yam bean.—Pachyrrhizus erosus (L.) Urb, *sincamas* (T., Pam.), *lincamas* (V.), *lancamas*. The tender, unripe pods are eaten in the same manner as beans. The roots, which are similar to the turnip in appearance, are eaten raw as a salad or cooked like the turnip. They are not well known.

Coriander.—Coriandrum sativum L., *unsuy* (T.). The young, tender leaves are added to *pansit*, a dish made from *bihon, misua,* or *mique*, and meat, such as pork or lobster, or are cooked with meat. The fruits are used for flavoring purposes, for flavoring candy, alcoholic drinks, and various preserves.

Celery.—Apium graveoleus L., *kinchay* (T.), *quiamse* (Pam.). Celery is used in salads and soups and is eaten with salt. It is an excellent relish and as it grows readily should be much more common as an article of diet.

Endive.—Chichorium endivia, escarola (T.). Endive grows well in the Philippine Islands during the cool season. It is eaten as a salad the same as lettuce.

Garlic.—Allium sativum L., *bauang* (T., Il., V., Pam.). Garlic is very generally used in oriental countries for flavoring meats and stews.

Sugar pea.—Pisum sativum L., *chicharro* (T., Pam.), *guisantes* (Il., V.). The sugar pea grows readily in the Philippine Islands, and if the pods are kept picked before they ripen, it is very productive. The young tender pods are boiled in preparing them for food.

Lima bean.—Phaseolus lunatus L., *patani* (T., Il., V.), *bule* (Pam.). The Lima bean is the best edible bean that is grown in the Philippine Islands. It is easy to raise, bears well, and if properly cared for will produce pods for a year or longer.

Parsley.—Petroselinum sativum, peregil (T.). Parsley is used to flavor soups or stews or to garnish meats and salads.

Leek.—Allium porrum L., *cuchay* (T. Il.), *suche* (Pam.). Leek is used to flavor soup and stews in the same way as garlic.

Pigweed.—Amaranthus oleraceus, culitis (T., V.). Pigweed is sold in the local market (Manila) and is prepared for food in the same manner as spinach.

Carrot.—Daucus carota L., *carot* (Sp.), *zanahoria* (T.). The carrot thrives best in the highlands, but it can be grown successfully in the lowlands also. Carrots are very appetizing when cooked in the same way as sweet peas and improve the quality of soups and stews when added to these.

Kale.—Brassica sp., *colis maluco* (T.). Kale is a variety of cabbage with curly, fleshy leaves that do not form a head. The leaves and stems are eaten as a salad or are stewed in the same manner as cabbage.

Onion.—Allium ceha, sebuyas (T., Pam.), *lasona* (Il.), *cebuyas* (V.). Much difficulty is experienced in raising large onions in the tropics, but small onions can be produced very readily. These are useful for flavoring soups or salads or may be eaten raw.

Cassava.—Manihot utilissima Pohl, *camoting cahoy* (T., V., Pam.). Cassava grows readily in the Philippine Islands, but at present is utilized for feeding hogs and only to a minor degree as an article of food for man. Considerable prejudice prevails regarding its use as a food owing to the presence in it of a cyanogenetic glucoside which gives off free prussic acid when allowed to stand or to ferment. As cooking destroys the activity of the accompanying enzyme that liberates the prussic acid, no evil effects should be experienced in its use as an article of food when cooked.

It is the source of one of the finest starches, consequently feeding it to hogs is an extravagance that should not be practiced, but it should be used for the preparation of commercial starch. The glucoside can be eliminated in the preparation of commercial starch by very careful washing.

Japanese mongo.—These beans are of various colors—green, yellow, or black. They are an excellent food to accompany rice because of their high protein content. They are cooked and eaten or may be mixed with shrimp and batter and made into a fritter. As this plant belongs to the legumes, its cultivation would be excellent for the improvement of the soil.

Pechay.—*Brassica chinensis* L., *pechay* (Sp., Il., T., V., Pam.). Pechay is one of the best vegetables for greens. It can be raised any time during the year and should thus be available at all times for the table. Unfortunately it is not cultivated extensively.

Chinese mustard.—*Brassica juncea* L. var., *mostaza* (Sp., Il., T., V., Pam.). Chinese mustard is used in the same way as pechay and is no more plentiful.

Cabbage.—*Brassica oleracea* L., *repollo* (Sp., Il., T., V., Pam.). Cabbage is scare in the lowlands, but is raised to some extent in the higher altitudes. The price of cabbage is too high for the poorer inhabitants.

Pasao.—*Corchorus olitorius* L., *saluyot* (Il.), *pasao* (T.), *lamhay* (V.). Pasao is another plant used in the same way as spinach. It is a common and widely distributed species in all settled areas of the Philippines.

Fern shoots.—*Athyrium esculentum* Copel., *pacó* (T.). This plant grows wild and is prepared for food, the young fronds being used in the same manner as spinach. It is also commonly eaten uncooked as a salad.

Taro.—*Colocasia antiquorum* Schott, *gabi* (Sp., T., V.), *aba* (Il.), *gandus* (Pam.). Taro has one parent root from which grow many smaller tubers. These tubers will keep for several months if they are sound when stored. They are prepared for food in the same way as sweet potatoes and are comparatively plentiful.

Chinese white radish.—*Raphanus sativus* L., *rabano* (Sp., Il., T., V., Pam.). Radishes are eaten raw, but very often they are cooked with yams.

Pungapong.—*Amorphophallus campanulatus* Blume, *tigui*

(Il.), *pungapong* (T.). This plant is locally very abundant, but is not cultivated. The young stems are cooked and eaten, but cannot be used raw on account of the presence of myriads of minute stinging crystals of oxalate of lime. The tubers are also sometimes used for food and for feeding hogs.

Bamboo shoots.—*Caña* (Sp.), *rabong* (Il.), *labong* (T., Pam.), *tambo* (V.).

Banana-flower buds.—*Musa sapientum* L., *corazon* (Sp.), *susup* (Il.), *puso nang saguing* (T., Pam.), *puso* (V.). Bamboo shoots and banana-flower buds are used only in making salads. Bamboo shoots are abundant and cheap because of the plentifulness of bamboo and the quick growth of the sprouts. Only the young shoot is used in this preparation.

The bud of the banana is plentiful, but as cutting the bud from the plant means the loss of a bunch of bananas, one understands why its use for salads is not more general. Both of the above make delicious salads.

A study of the cost of the vegetables examined shows that the price is relatively high. This condition will continue until each inhabitant has learned to have his own vegetable garden. In a climate such as this, where vegetation flourishes the year around, garden produce should be plentiful and the prices reasonable. Certain kinds of greens are cheap in a sense, but when one considers their food value they are found to be good for use only as a relish. Parts of the year some of the people are dependent on such greens for sustenance, because they have not yet learned the food value of the various vegetables.

The highest percentage of protein and highest food value are given by the various beans. In a country where large quantities of rice, composed chiefly of carbohydrates, are consumed, a food containing a high percentage of protein and some fat should supplement the diet. Native meat other than fish and chicken is scarce, and when one considers the high price of this commodity throughout the world, it would appear to be necessary to obtain a substitute for it in the diet. If the protein and fat food requirement is to be dependent on meat for fulfillment, the poorer people can hardly look forward to enjoying a more nearly perfect diet. An ideal food of this type is the soy bean. However, officials of the Philippine Bureau of Agriculture inform me that they have not succeeded in profitably growing the soy bean in the Islands. But they have not given up hope of ultimately succeeding and doubtless have good chances of eventually accomplishing their aim, since there are so many varieties of this bean that one or several of them are almost sure to grow here.

TABLE I.—*Analyses of the commonest Philippine vegetables used as food as purchased in the Manila market and their approximate cost and food values.*

Vegetable.[b]	Water.	Ether extract.	Protein N X 6.25.	Ash.	Crude fiber.	Carbohydrate (by difference).	Approximate cost of 1 kilo of food.	Cost of 1 kilo of protein.	Food needed to obtain 1 kilo of protein.	Calories per kilo of food.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Pesos.*[b]	*Pesos.*	*Kilos.*	
FRUITS.										
Eggplant (talong)	90.98	0.45	1.07	0.54	0.82	6.14	0.14	13.09	93.5	437.5
Squash (calabaza)	87.20	0.43	1.33	1.01	0.70	9.33	0.16	12.03	75.2	477.1
Cowpea (sitao)	86.75	0.18	2.65	0.90	2.03	7.49	0.20	7.55	37.7	452.5
Sponge gourd (patola)	94.58	0.13	0.63	0.28	0.13	4.25	0.11	17.46	158.7	212.2
Bottle gourd (upo)	95.44	0.09	0.50	0.37	0.26	3.34	0.11	22.00	200.0	165.8
Horse-radish tree (malungay)	88.24	0.16	7.29	0.94	0.76	2.61	0.18	2.47	13.7	320.8
Chick-pea (garbanzos)	13.63	5.38	19.94	2.86	2.26	55.93	0.44	2.20	5.0	3,611.1
Tomato (camatis)	94.32	0.23	0.99	0.62	0.64	3.20	0.16	16.16	101.0	191.2
Cowpea seed (mongo)	9.21	0.88	18.30	4.23	4.89	62.49	0.22	1.21	5.5	3,394.2
Breadfruit (camansi)	89.16	0.55	2.24	0.88	1.09	6.08	0.22	9.83	44.7	392.3
Tomato (camatis na ligao)	90.59	0.19	1.76	1.03	2.38	4.05	0.12	6.78	56.5	255.9
Batao (batao)	87.56	0.25	3.32	0.95	1.73	6.19	0.16	4.83	30.2	413.2
Papaya (papaya)	93.98	0.17	1.09	0.41	0.65	3.70	0.07	6.42	91.7	212.2
Cucumber (pepino)	94.14	0.19	0.52	0.46	0.30	2.39	0.22	42.31	192.3	137.0
Common bean (habichuelas)	15.07	1.70	18.09	3.80	4.28	57.06	0.35	1.93	5.5	3,239.3
Mongo seed (Japanese mongo)	14.70	0.93	20.44	3.01	4.36	56.56	0.35	1.72	4.9	3,243.5
Amargoso (ampalaya)	92.73	0.03	1.26	0.68	0.12	5.18	0.22	17.60	80.0	266.8
Winged bean (ciguidillas)	91.70	0.53	1.83	0.62	--------	--------	0.25	13.66	54.7	--------
Sugar pea (guisantes)	85.08	0.26	3.88	0.72	1.35	8.71	0.60	15.46	25.8	540.4
Lima bean (patani) fresh seed	65.50	1.26	7.30	1.84	0.77	23.37	0.40	5.48	13.7	1,374.7
Wax gourd (condol)	95.90	0.46	0.17	0.37	0.54	2.56	0.06	29.41	588.2	154.7
Sprouted cowpea (tógue)	92.85	0.45	2.38	0.41	0.69	3.91	0.05	2.10	42.0	299.8
LEAVES.										
Cangcong (cangcong)	89.70	0.04	4.25	1.67	0.70	3.64	0.18	4.23	23.5	327.2
Pepper (sili)	84.63	0.70	5.48	2.25	0.34	5.60	0.22	4.03	18.8	519.8
Sweet potato (camote)	84.20	0.42	1.15	1.98	1.90	10.25	0.35	20.45	87.0	505.2
Pechay (pechay)	92.97	0.34	1.00	1.26	0.79	4.64	0.22	20.00	100.0	262.9

Pasao (pasao)	80.61	0.44	5.07	2.77	1.81	9.30	0.22	4.33	19.7	630.1
Chinese mustard (mostaza)	91.30	0.31	2.06	1.10	0.80	4.43	0.22	10.58	48.1	304.9
Squash (calabaza)	89.45	0.34	4.07	1.87	1.16	3.11	0.35	8.61	24.6	326.0
Amargoso (ampalea)	81.94	0.13	2.30	2.06	0.75	16.82	0.22	9.57	43.5	796.0
Fern (pacó)	90.78	0.28	3.11	1.14	1.23	3.54	0.22	7.08	32.2	298.7
Cabbage (repollo)	91.86	0.28	2.03	0.79	0.91	4.13	0.35	17.26	49.3	278.6
Horse-radish tree (malungay)	76.67	1.10	7.30	2.14	1.75	11.04	0.12	1.64	13.7	854.3
Cowpea (sitao)	85.88	0.40	4.07	1.68	1.90	6.17	0.16	3.94	24.6	459.1
Coriander (unsuy)	90.82	0.41	2.17	1.38	0.79	4.43	0.20	9.22	46.1	308.7
Celery (kinchay)	92.72	0.32	1.65	1.56	0.86	2.89	0.20	12.00	60.6	215.0
Endive (escarola)	93.25	0.23	1.62	0.94	0.95	3.01	0.25	15.00	61.7	211.2
Garlic (bauang)	88.01	0.32	2.20	1.03	1.17	7.27	0.25	12.36	45.5	417.8
Parsley (peregil)	85.70	1.39	3.82	2.75	1.52	4.82	0.20	5.24	26.2	493.5
Leek (cuchay)	91.92	0.55	1.88	0.92	1.10	3.63	0.30	15.96	53.0	277.1
Pigweed (culitis)	83.35	1.71	3.98	2.44	1.53	6.99	0.07	1.75	25.1	608.7
Pigweed (colis maluco)	81.38	0.57	4.50	3.16	2.00	8.39	0.10	2.23	22.2	581.5
Young onion (cebuyas)	89.14	0.34	1.27	0.74	1.80	6.71	0.50	39.00	78.7	358.8
ROOTS.										
Sweet potato (camote)	71.20	0.52	0.65	0.91	1.35	23.37	0.14	21.55	153.9	1,033.2
Taro (gabi)	63.21	0.39	1.29	1.01	1.59	33.51	0.14	10.75	77.5	1,457.1
Yam (ube)	63.70	0.05	2.86	1.45	1.03	27.31	0.14	4.90	35.0	1,241.6
Chinese radish (rabano)	94.14	0.16	0.82	0.69	0.55	3.64	0.12	14.64	122.0	197.8
Pungapong (pungapong)	74.81	0.38	5.10	0.73	0.61	14.77	0.05	0.98	19.6	850.0
Yam bean (sincamas)	84.47	0.12	0.82	0.38	0.28	8.93	0.05	6.10	122.0	410.9
Carrot (carót)	86.36	0.23	2.26	0.80	1.27	9.08	0.15	6.64	44.2	486.3
Yam (tuguí)	67.49	0.19	1.50	1.07	0.95	18.80	0.15	10.00	66.7	850.0
Casava (camoting cahoy)	------	------	0.82	------	------	------	0.05	6.10	122.0	------
SHOOTS.										
Bamboo shoot (labong)	92.77	0.51	1.76	0.55	0.17	4.24	0.16	9.09	56.8	293.4
FLOWERS.										
Banana flower (puso nang saguing)	92.67	0.31	1.99	1.02	0.66	3.35	0.35	17.61	50.3	227.8
Caturay (caturay)	88.75	0.92	1.97	0.79	------	------	0.20	10.15	50.6	------

[a] Edible portion only.

[b] Words in parenthesis are the names of vegetables as used by people in the markets of Manila.

[c] One peso Philippine currency equal 50 cents in United States currency.

CONCLUSION

The people should be taught the relative nutritive values of the various foods they are eating.

The work of the Bureau of Education in encouraging the establishment and cultivation of gardens should be furthered so that every household, wherever possible, will have a garden of its own.

A plant such as the soy bean should be introduced, in order that the people may have a food which eaten with their rice and camotes will give them a more nearly balanced diet.

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IPEL, A COFFEE SUBSTITUTE: LEUCAENA GLAUCA (LINNÆUS) BENTHAM[1]

By HARVEY C. BRILL
(From the Laboratory of Organic Chemistry, Bureau of Science, Manila, P. I.)

The use of *Leucaena glauca* as a substitute for coffee has recently been brought to our attention by the Philippine Bureau of Education. The supervising teacher of Bauang, La Union Province, reports that several of his teachers have used it instead of coffee with pleasant results.

Leucaena glauca (L.) Benth., known as *ipel,* or *ipel-ipel,* among the Tagalogs, is widely distributed throughout the Philippine Islands, although it is not native, having come originally from tropical America. Merrill[2] says of this species:

> A native of tropical America, now widely distributed in tropical and subtropical parts of the world; very abundant and widely distributed in the Philippines at low altitudes, the timber being used for house posts and for firewood. In Leyte the seeds are used by the natives as a substitute for coffee.

The Spanish name *Santa Elena* is in common use throughout the Islands, while the following names are used in the localities indicated: *Aghó* (Iloilo Province, Panay); *datels* (Leyte); *comcompitis* (Ilocos Sur); *adjog* (Negros); and *ipel* (Cavite, Pampanga, Rizal, Nueva Ecija). The last name should not be confused with "ipil," which is the name of one of our important timber trees, *Intsia bijuga* O. Kuntze. *Leucaena glauca* Benth. has attained considerable prominence because of its value as a reforestation crop.

About 40 per cent of the total land area of the Philippine Islands has become covered with grass to the exclusion of practically all other vegetation. Areas such as these are difficult to reforest, and are not cultivated, owing to the frequency of fires and the ease with which cogon—the dominant grass occupying these tracts—crowds out the other vegetation. Cogon possesses a dense mass of underground stems, which spreading throughout the upper layer of the soil deprive it of nearly all the available moisture during the dry season. The removal of the grass for the purpose of reforestation is impracticable, because of the cost, and few trees are able successfully to compete with the cogon. Ipel, however, can thrive under these conditions, and owing to its habit of growing in thickets, soon chokes out the grass. Other trees can be successfully grown among the ipel. Indeed the presence of ipel is an advantage, since it serves as a shade to the young tree and raises the height at which the tree sends out branches.

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[1] Received for publication November 23, 1915.

[2] *This Journal, Sec. C* (1910), 5, 30.

While ipel is not so valuable a firewood as the *bacauans* (the mangrove trees), yet, in the growing scarcity of these and the demand for a quick-growing firewood for sugar centrals, etc., its value here will eventually increase.

Another factor worth considering is the improvement of the soil brought about by the cultivation of ipel. Since it belongs to the legumes, it possesses the property common to the members of this family of fixing the nitrogen of the air and making it available for plant growth. The shrub, or small tree, grows to a height of from 2 to 6 meters, in rare cases 10 meters, and bears thin, flat pods, from 12 to 18 centimeters long, within which are from fifteen to twenty-five small, shining, flattened brown seeds about 8 by 4 by 1.5 millimeters in dimensions.

These seeds when roasted and ground produce a reddish brown powder, having a color very similar to that of coffee and with an odor somewhat resembling the aroma of coffee. The odor of the infusion with water resembles the odor of coffee more closely than does that of the ground, roasted bean. This infusion is brown by direct light and has a deep green fluorescence by reflected light. It gives a violet color, but no precipitate with ferric chloride solution; with solutions of potassium-mercurio-iodide, potassium hydroxide, picric acid, iodine-potassium iodide, tannic acid, and Fehling it gives no precipitates. When warmed first with hydrochloric acid and then tested with Fehling's solution, it gives a precipitate of reduced copper oxide. Copper acetate produces a greenish brown, gelatinous precipitate with a dark green, supernatant liquid. Lead acetate gives a brownish yellow, gelatinous precipitate. The infusion is slightly acid to litmus and gelatinizes albumen.

Graham, Stenhouse, and Campbell proposed to take the density of different infusions of coffee and adulterants as a guide to the adulteration. They gave the following data for solutions made by treating the substance with ten times its weight of cold water, boiling, filtering, and then determining its density at 60° F.

TABLE I.—*Specific gravity of extracts of coffee and coffee adulterants.*[a]

Substance.	Specific gravity.	Substance.	Specific gravity.
Spent tan	1.00214	Carrots	1.01710
Lupine seed	1.00570	Bouka	1.01850
Acorns	1.00730	Black malt	1.02120
Peas	1.00730	Turnips	1.02140
Mocha coffee	1.00800	Rye meal	1.02160
Beans	1.00840	Dandelion root	1.02190
Neilgherry coffee	1.00840	Red beet	1.02210
Plantation Ceylon coffee	1.00870	English chicory	1.02170
Java coffee	1.00870	Yorkshire chicory	1.01910
Jamaica coffee	1.00870	Foreign chicory	1.02260
Costa Rica coffee	1.00900	Guernsey chicory	1.02326
Native Ceylon coffee	1.00900	Mangel-wurzel	1.02350
Brown malt	1.01090	Maize	1.02530
Parsnips	1.01430	Bread raspings	1.02630

[a] Blyth, Foods: Their Composition and Analysis, 6th ed. Charles Griffin & Co. Ltd., London (1909), 360.

The density of an infusion of ipel made and determined under these conditions is 1.00680. This density would place it between lupine seed and acorn in Table I and would serve as one means of identification. The roasted seed gave 24.4 per cent extract, soluble in water when treated in this manner. König[3] gives for coffee 21.12 per cent to 27.28 per cent. The ground, roasted seed when floated on strong salt water, cooled to a low temperature, in the course of a half hour sinks to the bottom of the cylinder. As it falls to the bottom, it leaves a trail of color. This color is not as intense as the color produced by chicory.

The analyses of the powder from the roasted and raw beans, along with that given by König[4] for coffee, are shown in Table II.

TABLE II.—*Analyses of ipel and coffee.*

[Numbers give percentages.]

	Ipel.		Coffee.	
	Raw.	Roasted.	Raw.	Roasted.
Moisture	14.80	8.13	10.73	2.38
Fat (ether extract)	8.68	6.95	11.80	13.85
Nitrogen	6.42	5.21	2.32	2.60
Sucrose	trace	trace	7.62	1.31
Nitrogen free material other than fiber	9.78	16.11	20.30	39.38
Crude fiber	22.29	22.18	24.01	18.07
Ash	4.20	4.37	3.02	4.65

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[3] Die menschlichen Nahrungs- und Genussmittel. 4th ed. Julius Springer, Berlin (1904), 2, 1072.

[4] Loc. cit.

The oils extracted from the roasted bean and from the raw bean have the indices of refraction and the saponification numbers given in Table III.

TABLE III.—*The constants of the oils of ipel and those of coffee.*[a]

	Index of refraction.	Saponification.
Ipel:		
Raw	1.4670	196.2
Roasted	1.4690	190.7
Coffee:		
Raw	1.4695	157.2
Roasted	1.4715	162.6

[a] König, loc. cit.

DISCUSSION

Ipel has no possibility of becoming of any great commercial value, but it has a local significance. Viewed in relation to the world's production of coffee, it is infinitesimally insignificant.

TABLE IV.—*Average annual production of coffee by continents. Years, 1906–1910.*

Continent.	Pounds.
South America	2,021,805,000
North America	384,138,000
Asia	92,818,000
Africa and Oceania	21,998,000

The properties of ipel are discussed here because of its local use as a coffee substitute or adulterant.

THE CHEMICAL PURIFICATION OF SWIMMING POOLS *

By GEORGE W. HEISE and R. H. AGUILAR

(From the Laboratory of General, Inorganic, and Physical Chemistry, Bureau of Science, Manila, P. I.)

TWO TEXT FIGURES

The purification of swimming pools has long been the subject of much study, and a vast literature has been developed concerning it. Many methods have been suggested, notably filtration, sterilization with ultra-violet rays, and the use of ozone, copper sulphate, liquid chlorine, and the hypochlorites of sodium, magnesium, or calcium. Although these methods, or combinations of two or more of them, have been found satisfactory under most conditions, great discrepancies exist in the results recorded. In spite of the fact that there are many factors influencing the purification of swimming pools, many experimenters have treated their particular problems as though they were of general application; hence has arisen much difference in opinion concerning the relative merits of different purifying agents, amounts necessary for efficient purification, methods of application, and the like. In many cases too little attention has been paid to important factors such as quality of water, temperature of pool, number of persons bathing, turbidity and the like to enable general conclusions to be drawn from the results of different workers. The treatment which is highly efficient for one water under certain conditions may fail utterly for a different water under slightly changed conditions.

Of the methods mentioned, the use of chlorine either as liquid chlorine or as a hypochlorite is probably the most widely practiced, and because of their cheapness and because of the ease with which they can be administered, hypochlorites are employed more than liquid chlorine.

The work here recorded was done (1) for the purpose of putting the swimming pools in Manila into a sanitary condition and (2) to study the factors influencing the chemical purification of swimming pools, with a view toward devising methods of chemical control. It is our purpose to discuss here only the chemical work done on this problem; the bacteriological work done in coöperation was performed by Dr. C. E. Gabel, of the Bureau of Science, and is recorded and discussed in detail separately.[1]

The three installations studied, which we shall designate as

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* Received for publication November 26, 1915.

[1] *This Journal, Sec. B* (1916), 11, No. 2.

I, II, and III, are of slightly varying depths and dimensions. Each of installations I and II has a capacity of about 200 cubic meters, and III has a capacity of about 225 cubic meters. Each is between 18 and 19 meters (60 feet) long, and has a depth of about 2.5 meters (8 feet) in the deepest portion. Installations I and II are situated indoors. Installation III, although covered by a roof and surrounded by a low, light wall of *sawale* (woven bamboo), is practically outdoors. Owing to building operations at III, the tank was not in continuous operation and foreign material fell into it, causing discrepancies in the results. These discrepancies, however, were not great enough to affect the general conclusions obtained.

The same water, direct from the Manila city supply system, was used in all three tanks. This is a river water, which is kept in storage for three days and treated, before it enters the city distribution system, with chloride of lime at a rate corresponding to an addition of 0.5 part of available chlorine per million parts of water.

As it leaves the pipes it is a slightly turbid water with a greatly fluctuating bacterial content. Its turbidity, due to very finely divided clay, varies from 7 to 15 parts per million, as measured by the United States Geological Survey turbidity-rod method. Its temperature, which shows slight variations at different seasons of the year, is usually between 27° C. and 30° C. A typical analysis of this water is shown in Table I.

TABLE I.—*Analysis of water from Manila supply system.*[a]

[Results expressed as parts per million.]

Total solids	154
Alkalinity (as $CaCO_3$)	100
Silica (SiO_2)	24
Iron and aluminium oxides ($Fe_2O_3+Al_2O_3$)	1.7
Calcium (Ca)	31
Magnesium (Mg)	6
Sodium (Na)	13
Potassium (K)	2
Normal carbonates (CO_3)	0–10
Bicarbonates (HCO_3)	100–120
Sulphates (SO_4)	14
Chlorides (Cl)	4
Nitrates (N)	0.046
Nitrites (N)	trace
Free ammonia (N)	0.03
Albuminoid ammonia (N)	0.116

[a] Analysis by V. Q. Gana, chemist, Bureau of Science.

The problem of maintaining a swimming pool in Manila in a sanitary and attractive condition is rather complicated. The water from the municipal supply is always slightly turbid, so that the bottom of a pool is generally invisible. This turbidity not only makes the pool unattractive and increases the danger from accidental drowning, but also militates against the action of disinfectants. The temperature (27°C. to 30°C.) is an added factor, as it is nearer the bacterial optimum than that of typical United States installations, and bacterial growth is correspondingly stimulated.

Obviously, filtration should be employed as a preliminary measure in the treatment of waters of the kind described; however, the lack of filtration facilities and the desirability of improving the sanitary condition of the local installations as rapidly as possible made it advisable to see what could be done with chemical methods. of purification alone.

In the series of experiments here recorded, chloride of lime, copper sulphate, and sodium hypochlorite (antiformin) were used for purification. The first was either added as a uniform emulsion or was placed in a bag and dragged through the water until thoroughly leached out; the last two were added in water solution.

The chemical and physical tests consisted in daily determinations of turbidity, temperature, and chlorides and oxygen-consuming capacity, with occasional determinations of total solids, alkalinity, and near the end of the work of factors influencing the chemical decomposition of hypochlorites. With the exception noted, the water was changed at the beginning of each week, and chemicals were added to the fresh water. The analytical data secured are recorded in Tables II to VII, inclusive.

TABLE II.—*Daily variation in quality of water. No disinfectant added.*

[Results expressed as parts per million.]

Age of water in days.	Pool I.[a]			Pool II.[b]		Pool III.[c]		
	Chlorides (Cl).	Oxygen consumed (O).	Turbidity.	Chlorides (Cl).	Oxygen consumed (O).	Chlorides (Cl).	Oxygen consumed (O).	Turbidity.
1	5.0	1.10	13.5	5.7	1.42	4.8	1.65	--------
2	4.9	0.9	8.5	4.9	1.03	4.9	1.86	--------
3	4.7	0.83	--------	4.7	1.05	4.3	1.21	15.5
4	4.6	1.01	8.4	4.9	1.00	4.6	1.32	14.5
5	4.7	0.92	8.4	4.8	1.00	5.0	1.37	15.0
6	5.1	0.97	8.8	4.8	1.00	4.4	1.42	15.5
7	--------	--------	--------	4.6	1.11	--------	--------	--------

[a] Average temperature, 27.0° C. Total bathers, 200.

[b] Average temperature, 28.5° C. Total bathers, 159.

[c] Average temperature, 27.5° C. Total bathers, 79.

TABLE III.—*Variation in quality of water. Addition: 1 part of $CuSO_4.5H_2O$ per million parts of water.*

[Results expressed as parts per million.]

Age of water in days.	Pool I.[a]			Pool II.[b]		Pool III.[c]		
	Chlorides (Cl).	Oxygen consumed (O).	Turbidity.	Chlorides (Cl).	Oxygen consumed (O).	Chlorides (Cl).	Oxygen consumed (O).	Turbidity.
1	7.5	1.12	11.5	4.9	0.98	4.7	1.20	11.7
2	4.8	1.37	10.5	4.7	1.23	5.3	1.52	11.3
3	5.0	1.00	10.7	5.5	1.44	4.4	1.32	11.3
4	4.7	0.97	10.5	5.8	1.47	4.6	1.42	9.7
5	4.6	1.18	10.5	6.0	1.85	4.5	1.64	10.5
6	4.6	1.05	9.7	5.8	1.80	....	....	....

[a] Average temperature, 28.5° C. Total bathers, 235.
[b] Average temperature, 27.5° C. Total bathers, 346.
[c] Average temperature, 28.5° C. Total bathers, 85.

TABLE IV.—*Daily variation in quality of water. Addition: 2 parts $CuSO_4.5H_2O$ per million parts of water.*

[Results expressed as parts per million.]

Age of water in days.	Pool I.[a]			Pool II.[b]		Pool III.[c]		
	Chlorides (Cl).	Oxygen consumed (O).	Turbidity.	Chlorides (Cl).	Oxygen consumed (O).	Chlorides (Cl).	Oxygen consumed (O).	Turbidity.
1	4.9	1.05	12.8	5.6	1.01	4.6	1.48	....
2	4.7	1.10	13	5.7	1.08	5.6	1.67	20
3	4.8	1.20	12	6.0	1.15	4.4	1.53	12
4	4.9	1.09	13.5	5.5	1.22	4.5	1.68	....
5	4.6	1.11	12.4	5.6	1.18	3.7	1.37	14
6	4.5	1.23	....	5.8	1.34	4.1	1.37	13
7	....	....	....	....	....	4.0	2.09	13
8	....	....	....	....	....	4.2	1.84	10

[a] Average temperature, 28.0° C. Total bathers, 259.
[b] Average temperature, 28.0° C. Total bathers, 233.
[c] Average temperature, 28.5° C. Total bathers, 112.

TABLE V.—*Daily variation in quality of water. Addition: 0.5 part of available chlorine (from chloride of lime) per million parts of water.*

[Results expressed as parts per million.]

Age of water in days.	Pool I.[a]		Pool II.[b]		Pool III.[c]	
	Chlorides (Cl).	Oxygen consumed (O).	Chlorides (Cl).	Oxygen consumed (O).	Chlorides (Cl).	Oxygen consumed (O).
1	5.5	0.7	4.5	1.0	5.0	0.75
2	4.2	0.8	4.0	0.7	5.7	0.7
3	4.5	1.5	5.0	0.9	6.1	0.72
4	4.5	0.7	5.0	0.88	6.5	1.39
5	5.3	1.34	5.3	0.87		
6	5.0	1.35	5.3	1.30		

[a] Average temperature, 27.5° C. Total bathers, 424.
[b] Average temperature, 27.0° C. Total bathers, 298.
[c] Average temperature, 28.0° C. Total bathers, 70.

TABLE VI.—*Variation in quality of water. Addition: 1 part of available chlorine (from chloride of lime) per million parts of water.*

[Results expressed as parts per million.]

Age of water in days.	Pool I.[a]		Pool II.[b]		Pool III.[c]	
	Chlorides (Cl).	Oxygen consumed. (O).	Chlorides (Cl).	Oxygen consumed (O).	Chlorides (Cl).	Oxygen consumed (O).
1	5.3	0.74	4.5	0.85	7.1	1.51
2	6.0	1.24	5.8	1.15	5.9	1.21
3	6.8	1.02	6.8	0.95	7.1	1.36
4	6.5	1.00	6.2	1.11	6.7	1.18
5	6.0	0.97	6.0	1.72	6.5	1.29

[a] Average temperature, 28.0° C. Total bathers, 223.
[b] Average temperature, 27.0° C. Total bathers, 231.
[c] Average temperature, 28.5° C. Total bathers, 152.

TABLE VII.—*Variation in quality of water. Addition: 2 parts of available chlorine (from chloride of lime) per million parts of water.*

[Results expressed as parts per million.]

Age of water in days.	Pool I.[a]			Pool II.[b]		Pool III.[c]			
	Chlorides (Cl).	Oxygen consumed (O).	Turbidity.	Chlorides (Cl).	Oxygen consumed (O).	Chlorides (Cl).	Oxygen consumed (O).	Turbidity.	Total solids.
1	4.9	0.99	--------	5.3	1.21	6.0	1.49	16.0	155
2	6.8	1.31	13	5.4	2.23	7.2	1.56	10.1	164
3	6.3	1.64	15	5.5	1.52	7.9	1.72	10.1	167
4	6.8	1.90	10	5.8	1.51	7.9	1.78	12.5	160
5	7.1	1.34	10.5	6.1	1.44	7.7	1.86	12.9	162
6	7.2	1.30	13.5	6.2	1.84	7.6	1.46	10.5	170

[a] Average temperature, 28.0° C. Total bathers, 295.
[b] Average temperature, 27.5° C. Total bathers, 204.
[c] Average temperature, 28.5° C. Total bathers, 80.

When water was left untreated in the local swimming pools, the bacterial count invariably reached enormous figures about the second day, and organisms of the *B. coli* group were practically always to be found in 1 cubic centimeter water samples after the first day. The usual chemical analyses gave little indication of this state of affairs (Table II). A slight sedimentation occurred during the first day or two in which the water was used, leading to a decreased turbidity and corresponding fluctuations in oxygen consumption and chloride content. Differences during the week in total solids and alkalinity, if any, were too slight to be of significance; neither chlorides nor oxygen consumed showed the steady increase which might have been expected; turbidity, after the initial drop, remained practically constant.

The use of copper sulphate as a disinfectant both for public water supplies and for swimming pools has frequently been recommended.[2] For example, Thomas,[3] in a recent article, showed that a greater degree of bacterial purification had been effected in a swimming pool with daily additions of 0.4 part per million of copper sulphate than had previously been accomplished with a single addition of 2.5 parts per million of "hypochlorite" [0.8 (?) part of available chlorine], and concluded that the copper sulphate method was cheaper and more effective, and was further superior to hypochlorite treatment because it caused no odor and was not irritating to the eyes. Unfortunately the author gives no data concerning the chemical quality of the water used nor the exact strength of hypochlorite employed. The water was filtered and refiltered, and alum was used as coagulant. As the author points out, the coagulation with alum and subsequent filtration removes the carbonates and bicarbonates which would otherwise hinder the action of copper sulphate.

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[2] For partial bibliography see Manheimer, *Publ. Health Report* (1915), 30, 2796.

[3] *Journ. Ind. Eng. Chem.* (1915), 7, 496.

Our results with copper sulphate show clearly the unsuitability of this method to a water high in substances which react with a copper salt. The test was conducted for two weeks, 1 part of crystalline copper sulphate per million parts of water being employed during the first week and 2 parts per million (with fresh water) during the second. In neither case was an effect on the bacterial content apparent after the first day, and long before the end of the week the colony count had reached an enormous figure, the copper sulphate seemingly exercising not the slightest inhibiting effect.

The chemical analysis of the water showed little or no variation (Tables III and IV). Upon addition of copper sulphate the turbidity of the water increased greatly, owing to interaction with the bicarbonates present and subsequent precipitation of hydroxides and carbonates of copper, calcium, or magnesium. This action would account for the removal of copper sulphate and its failure as a germicide in this series of tests. Owing to the turbidity resulting from its use and to the lack of efficient sterilizing action, it is apparent that, without filtration, the use of copper sulphate is not to be recommended for water similar to the one under observation.

A number of attempts were made to secure adequate purification with chloride of lime, different quantities being used each week.

The first attempt with chloride of lime was made with an addition of 0.5 part of available chlorine[4] per million parts of water. The effect on the bacterial content was apparent for only one day, after which the count was excessive and *B. coli* appeared. No better results attended the addition of 1 part per million, and only with an addition of 2 parts per million could an appreciable effect on the bacterial content on the second day be ascribed to the chemical added. After the second day the bacterial increase proceeded unchecked. In none of these cases was the effect on the chemical constituents great enough noticeably to affect the alkalinity or total solid content of the water (Tables V to VII).

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[4] All hypochlorite used was analyzed with arsenious acid, using starch-potassium-iodide paper as indicator.

It might be well to note parenthetically that although the last-mentioned concentration is far in excess of that generally employed for purification, there was no complaint from users of the pool, except in one case, where a few people complained of irritations of the eyes and of the mucosæ of nose and throat. In this instance it was shown that the trouble was due to careless and improper administration of the disinfectant, which allowed undissolved lumps to get into the tank. The odor was strong and persisted for days, but was not sufficiently disagreeable to be a real drawback to the use of hypochlorite.

The chlorination having failed to give the desired results, an attempt was made to study in detail the causes of the failure and to overcome the difficulties involved.

It was noticed that in general the city water showed no trace of "free chlorine" when it left the mains, as determined chemically by acidifying 200 cubic centimeter samples of water and adding a drop of methyl orange,[5] the presence of chlorine being indicated by the bleaching of the indicator. This result was rather surprising, since the water arrived at the swimming pools probably within three, almost certainly within five, hours after chlorination had taken place. Moreover, in spite of the relatively large additions of chloride of lime to the swimming pools, all trace of "free chlorine" was lost, usually within twenty-four hours.

A laboratory study of the decomposition of a clear (filtered) solution of chloride of lime added to (unchlorinated) city water gave the results indicated in Table VIII (fig. 1).

TABLE VIII.—*Decomposition of chloride of lime in water.*

Minutes.	Available chlorine in parts per million.
0	0.8
2	0.6
30	0.3
120	0.1 (?)

From the foregoing it is apparent that the chloride of lime lost its effective strength very rapidly and that in two hours its concentration had fallen below 0.1 per million. Just what is the minimum concentration of chlorine that will keep water free from dangerous organisms is not known; certainly it cannot be much less than the concentration mentioned above.

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[5] Winkler, *Zeitschr. f. angew. Chem.* (1915), 28, I, 22.

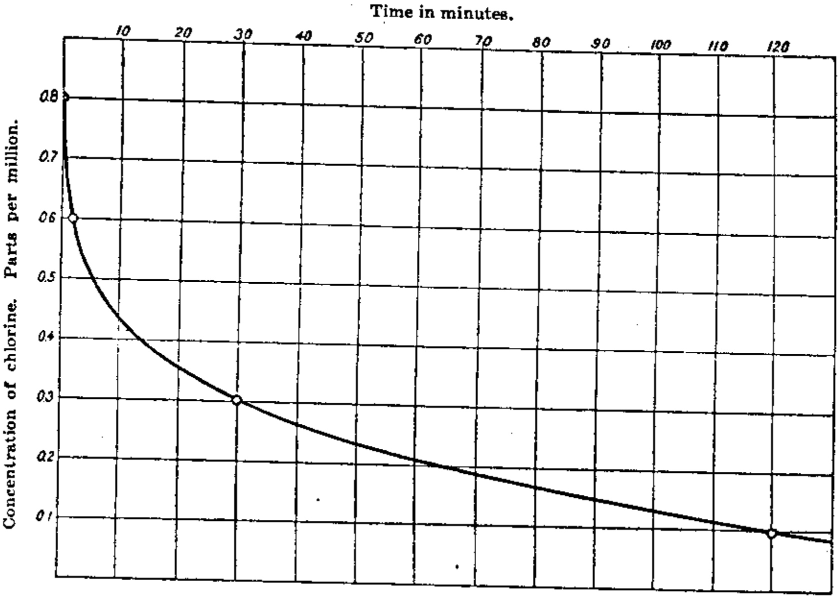

FIG. 1. Decomposition of calcium hypochlorite in water.

The destruction of hypochlorite must be due either to spontaneous decomposition or to interaction with substances dissolved in water. Hypochlorites decompose, even in the dark,[6] with measureable velocity. The reaction is greatly accelerated by light,[7] especially by the visible and ultra-violet rays, and by heat. The temperature of a bath, therefore, becomes a matter of no small importance in studying purification of water with hypochlorite, and the amount of daylight falling on a pool may greatly affect the rate at which hypochlorite disappears.

The interaction of chlorine with substances dissolved in water has been much studied in recent years.[8] The phenomenon is generally associated with a high organic content in water. A large amount of "free chlorine" disappears immediately, after which decomposition proceeds more slowly, but does not reach equilibrium for a long time. The amount of chlorine consumed appears to be dependent on the concentration in which it is added; the more hypochlorite added, the more will be decomposed in a given time. The reaction proceeds more rapidly at high temperature than at low.

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[6] Bhaduri, *Zeitschr. f. anorg. Chem.* (1897), 13, 385.
[7] Lewis, *Journ. Chem. Soc.* (1912), 101, 2371.
[8] Cf. Glaser, *Arch. f. Hyg.* (1912–13), 77, 165; Hairi, *Zeitschr. f. Hyg.* (1913), 75, 40.

Many substances are known[9] to affect the chlorine consumption, notably albumin and its decomposition products, urea, glycocol, peptone, asparagin, and the like. We have determined the chlorine-consuming power of a number of different substances, using the following method:

Two hundred cubic centimeter samples of water, or else the substances under examination dissolved in 200 cubic centimeters of distilled water, were placed in glass-stoppered bottles. To each sample a known excess of clear (filtered) calcium hypochlorite solution was added. The bottle was stoppered and allowed to stand at room temperature (30° C.) for two hours in the diffused daylight of the laboratory. After digestion with hypochlorite, 2 cubic centimeters of 10 per cent potassium iodide solution and 2 cubic centimeters of 25 per cent phosphoric acid were added to each sample, and the liberated iodine was titrated with 0.02N sodium thiosulphate solution, starch being used as an indicator.

The differences in chlorine consumption are shown in Table IX.

TABLE IX.—*Chlorine-consuming power of different substances.*

Substance.	Chlorine added.	Chlorine consumed.	Chlorine consumed per liter.	Remarks.
	mg.	*mg.*	*mg.*	
Distilled water	6.5	0.15	0.75	
Reservoir water (unchlorinated)	6.5	0.2–0.5	1.0–2.5	Varies from day to day.
Tap water (chlorinated)	6.5	0.2–0.6	1.0–3.0	Do.
Artesian well water	1.0	0.24	1.2	Bureau of Science well.
Sea water	6.5	0.75	3.75	From aquarium.
200 cubic centimeters distilled water:				
Plus 0.0025 gram oxalic acid	6.5	0.28	1.4	
Plus 0.005 gram oxalic acid	6.5	0.7	3.5	
Plus 1 cubic centimeter urine	6.5	4.4	22.0	
Plus 0.5 cubic centimeter ± sweat	6.5	5.6	28.0	
Plus 0.5 cubic centimeter saliva	3.4	2.0	10.0	

It is significant that the substances given off from the human body cause the consumption of relatively large amounts of chlorine. This emphasizes the necessity of personal cleanliness on the part of the users of swimming pools if the purification of tank water by means of chlorine is to be successful. A thorough bath with soap should be taken before the pool is entered to remove all body products so far as possible, not only to avoid introducing into the water substances noxious per se, but in order to prevent the destruction of the hypochlorites to which the purifying action is due.

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[9] Cf. Elmanowitsch and Zaleski, *Zeitschr. f. Hyg.* (1914), 78, 473; Hairi, ibid. (1913), 75, 46.

There are, then, two distinct actions or effects: the first, the germicidal action of chlorine or hypochlorites; the second, the specific interaction between the chlorine and the substances in water. There is evidently a minimum concentration below which effective purification does not occur; if this is reached in a short time, purification will not be adequate or lasting in its effect. It thus becomes necessary to maintain at all times in the water of a swimming pool an excess of "free chlorine" sufficient to keep up effective purifying action.

With these conditions in mind, the purification of a swimming pool becomes a comparatively simple matter. A relatively small amount of hypochlorite will effectively purify the water, after which it becomes necessary to keep the bacterial content within safe limits by means of repeated additions of disinfectant. That this is true is evinced by the results obtained during a series of tests in which chloride of lime was used in quantities representing a daily addition of 0.5 part of "available chlorine" per million parts of water. Throughout this series the bacterial content was kept below 200 and no *B. coli* was found. In all cases the water remained in the pools for two weeks and was safe during the entire period. That there was no cumulative effect and that there was no large excess of chlorine at any time were shown by omitting chlorination for a single day, when the bacterial content immediately increased to dangerous proportions. Throughout the two weeks qualitative tests for the presence of free chlorine and quantitative determinations of the chlorine-consuming power were made, with the results listed in Table X.

At first the chlorine consumption remained almost constant, next it passed through a minimum, and then, as people used the pool, it rose rapidly. Evidently it takes more and more chlorine to produce a given effect as time goes on; and therefore it becomes advisable to change the water after the chlorine consumption reaches a certain maximum, although just where that maximum should be placed is a matter of conjecture. The efficiency of the purifying action was such that it is clear that the maximum was not exceeded during the first week, nor in the case of tank I even during the second week. Chloride of lime, therefore, will keep a tank clean and reasonably safe for ten days or two weeks, even under the unfavorable circumstances existing in Manila; and if the water be changed weekly, the danger of contamination is very slight.

TABLE X.—*Effect of daily additions of 0.5 part of available chlorine per million parts of water.*

[Results expressed as parts per million.]

TANK I.[a]

Age of water in days.	Turbidity.	Qualitative test for free chlorine.	Chlorine-consuming capacity.[b]	Chlorides (Cl).	Oxygen consumed.
1			2.5	5.6	0.75
2	8.4	Strong			
3	8.5				
4	9.5	Faint			
5	7.0				
6	8.7				
7	8.5	Faint			
8			2.8		
9	8.8		1.1		
10	8.1	Faint	1.05		
11	8.8	do	0.7		
12	8.5	do	1.0		
13	9.1	Very faint	1.0		
14	8.5	do		13.0	1.05
15					
16		Negative			

TANK III.[b]

1	10.5		2.5	4.4	1.42
2	8	Very faint			
3	11.5	do			
4	8.9				
5		Negative			
6	9.9		3.0		
7	9.1		3.0		
8			2.1		
9	8.3		3.1		
10	8.5		3.5	12.2	2.36
11					
12		Negative			

[a] Tank I was chlorinated daily at 9 o'clock in the forenoon; tank III at 4 o'clock in the afternoon; both were sampled at 6 o'clock in the afternoon and analyzed the following day.

[b] Two hundred cubic centimeter samples digested two hours at 30° C. with 6.5 milligrams available chlorine.

It was inadvisable to keep the water in the tanks for more than one week, for the additional reason that the amount of calcium chloride introduced might prove objectionable. In the cases under observation there was not the slightest complaint during the two weeks' run. The odor of chlorine was usually marked (even in some cases where it could not be detected chemically), but was not strong enough to be objectionable.

A second run of one week's duration in tank III, using the same daily addition of 0.5 part of chlorine per million parts of water, substantiated our conclusions throughout. In this run conditions were markedly improved, probably because of the partial cessation of building operations. There was generally a sufficient excess of chlorine in the pool to give a reaction with potassium iodide and starch in the presence of phosphoric acid. The bacterial count was low throughout the week. The chemical data secured are shown in Table XI.

TABLE XI.—*Effect of daily additions of 0.5 part of chlorine per million parts of water. Tank III.*[a]

[Results expressed as parts per million.]

Age of water in days.	Turbidity.	Qualitative test for free chlorine.	Available chlorine present.	Chlorine consumption.[b]
1	9.9	Positive		2.5
2	9	do		
3		do	trace	0.35
4	8.7	do	0.2	1.2
5	7.8	do	0.30	2.4
6	<7	do	0.35	1.75

[a] Chlorination occurred daily at 4 o'clock in the afternoon; the sample was taken at 6 o'clock in the afternoon and analyzed during the following morning.

[b] Two hundred cubic centimeter samples digested two hours at 30° C. with 3.5 milligrams available chlorine.

Although the results of turbidity measurements are somewhat conflicting, it is evident that there was a slight clearing of the water due to the addition of chloride of lime. In spite of the amount of disinfectant added, no bad effect on the swimmers was noted and no complaint was made.

A series (on tank I) was performed, substituting sodium hypochlorite (as antiformin) for calcium hypochlorite. Unfortunately a weak solution was used, so that bacteriologically the results left much to be desired; however, there can be no question that in proper concentration it would have given efficient purifying action. Sodium hypochlorite has the advantage that it introduces no calcium salts or irritating substances into water, and the results of this work indicate that, for Manila water at any rate, a large amount of clearing of water occurs. The chemical data secured are shown in Table XII.

TABLE XII.—*Effect of adding antiformin.*

[Results expressed as parts per million.]

Age of water in days.	Turbidity.	Qualitative test for free chlorine.	Chlorine consumption.[a]
1	8.5	Negative	--------
2	<7	do	--------
3	<7	do	1.0
4	<7	do	2.4
5	<7	do	2.8
6	<7	do	4.2

[a] Two hundred cubic centimeter samples digested two hours at 30° C. with 3.5 milligrams available chlorine.

In order to ascertain whether the quantity of disinfectant could be appreciably diminished without destroying the sterilizing efficiency of the hypochlorite, a final series was attempted, using daily additions of 0.25 part of available chlorine per million parts of water. It developed that, although tank I was kept sterile by this treatment, the bacteria count in tank III showed a rather alarming increase after about three days, in spite of the fact that tank I is used by more bathers than tank III. The building operations at tank III introduced disturbing factors; however, there can be little question that in this case light was the chief cause of the discrepancies noted. Tank III is built practically out of doors, and during the last week's run was open to the sky. The sunlight had sufficient accelerating effect on the decomposition of the hypochlorite to bring the available chlorine below the effective sterilizing strength in a short time.

The effect of additions of 0.25 part of available chlorine per million parts of water is shown in Table XIII. Chlorine consumption was determined by digestion both in the dark and in the diffused daylight of the laboratory. The differences noted in the two determinations give some indication of the marked effect of light.

It is doubtful if such high concentrations of hypochlorite as those used in Manila would be necessary under average conditions. In addition to the poor quality of the water, the added effects of excessive temperature (almost 30°C.) and of light must be taken into account. Even in the tanks under observation, where conditions were fairly uniform, each case required special treatment. Tank III, the best lighted, requires greater additions of chlorine to maintain an excess of disinfectant than does tank I, while in tank II, the most poorly lighted, the decomposition rate of hypochlorite is below that in the others. This furnishes explanation for the fact that the treatment with 0.5 part of chlorine, found necessary in tank III, was greater than the requirement for tank I, while the same treatment in tank II caused numerous complaints of excessive and disagreeable odor.

TABLE XIII.—*Effect of daily additions of 0.25 part of chlorine per million parts of water.*

[Results expressed as parts per million.]

TANK I.

Age of water in days.	Turbidity.	Qualitative test for free chlorine.	Chlorine present.	Chlorine consumed.[a]	
				Dark.	Light.
1	[b] 11	Positive	Trace	0.6	1.4
2	13	do	do	[c] 0.7	[c] 0.7
3	10	Negative	Nil	1.2	2.5
4	8	do	Negative	1.2	3.3
5	11	do	do	1.2	3.5
6	9	do	do	1.2	2.5
TANK III.					
1	15	Negative	Nil	1.25	2.3
2		do	do	[c] 2.3	[c] 2.3
3		do	do	2.3	3.3
4	20	do	do	2.2	4.4
5	20	do	do	2.1	4.2
6	15	do	do	1.5	3.2

[a] Two hundred cubic centimeter samples digested two hours at room temperature with 2.8 milligrams available chlorine.

[b] Immediately after chlorination.

[c] Dull day.

In disinfecting municipal water supplies or sewage there is a certain quantity of contaminating material present; once this is destroyed or removed, there is usually no further influx of noxious matter. Glaser,[10] in contradiction of the findings of Grether,[11] concluded that a single addition of disinfectant is as efficaceous as the same amount added at intervals in smaller quantities. His results may be correct for ordinary water or for sewage, but it is obvious that different conditions obtain for swimming pools, where the contaminating substances are being continually added. In the latter case the periodic addition of chlorine in small quantities, but sufficiently great to effect purification, is not only preferable, but even necessary, to provide adequate protection to people using the pool. The fractional addition has the further advantage that the objectionable features of high dosage (odor, irritation of mucosæ, and the like) are largely eliminated.

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[10] *Arch. f. Hyg.* (1912), 77, 279.

[11] Ibid. (1896), 27, 189.

Obviously the water in a swimming pool should be as clear as possible, not only because clear water makes a pool more attractive and lessens the danger of accidental drowning, but also because it is more susceptible than turbid water to the disinfecting action of chlorine. Therefore water should be subjected to filtration, with or without coagulation, wherever practicable. Aside from its coagulating effect, the action of alum is beneficial in that it reacts with bicarbonated waters in such a way that the action of chloride of lime or copper sulphate is interfered with as little as possible.

The basic carbonates, which would otherwise form precipitates with copper sulphate or chloride of lime, preventing germicidal action in the case of the former by removing copper from the sphere of influence, and causing cloudiness of the water in both cases, are removed. The addition to tank III of 1 part of alum per million parts of water had the effect shown in Table XIV.

TABLE XIV.—*Effect of alum.*

[Results expressed as parts per million.]

	Turbidity.	Total solids.	Oxygen consumed.
Before addition of alum	14	164	1.51
Twelve hours after addition of alum	10	112	1.04
Reduction in percentage	28	31	31

An attempt was made to correlate the analytical chemical data with the biological, with a view toward establishing chemical methods of determining the state of purity of water in a pool. It must be admitted that little success was achieved. The oxygen consumption showed no traceable relation either to bacterial content or to chlorine-consuming power, and even the variation in chloride content failed to give reliable data on contamination. It may be that the intermittent settling and stirring up of the suspended matter which causes the high turbidity greatly influenced the analytical results; at any rate, differences noted were neither uniform nor great enough to justify conclusions. That a relation does exist is shown by the comparison between the number of bathers a week and the oxygen-consuming capacity at the end of the week, as shown in Table XV and fig. 2. The comparison was made only for tank I, as this is the installation on which the most reliable data concerning the number of bathers were obtained.

TABLE XV.—*Variation in quality of water, compared with number of bathers. Tank I.*

Week.	Series No.[a]	Average daily attendance.	Oxygen consumption (parts per million).[b]
First	4	70	1.34
Second	5	37	0.98
Third	6	49	1.32
Fourth	2	39	1.11
Fifth	3	43	1.17
Sixth	1	33	0.95

[a] As given in Tables II to VII.

[b] Average of readings of last two days.

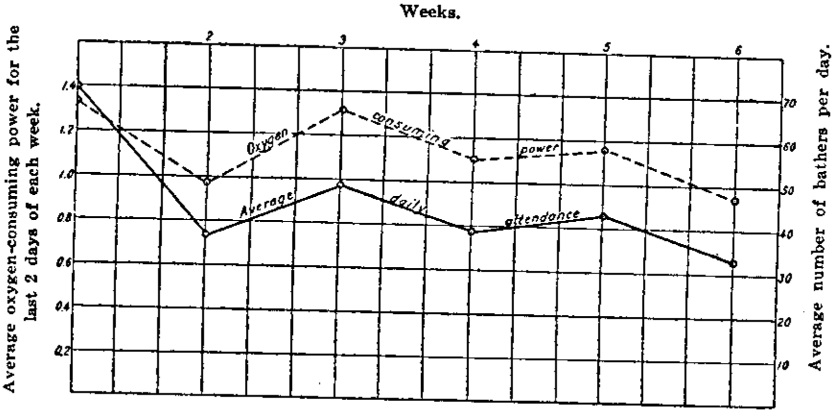

FIG. 2. Relation between oxygen consumption and number of bathers.

Therefore we may conclude that the most significant simple tests on the waters of swimming pools, in addition to the bacteriological examinations, are the determinations of available chlorine and of chlorine-consuming capacity. Once the quality of the water with respect to its chlorine-binding power has been established, it should be an easy matter properly to regulate the dosage. The qualitative test for chlorine is then enough for control purposes, as it shows whether a sufficient concentration of chlorine is being maintained and indicates any sudden variations which might be caused by occasional abnormal contaminations.

SUMMARY AND CONCLUSIONS

The chemical purification of swimming pools has been studied with special reference to the action of copper sulphate and chloride of lime.

The work was done on water that was turbid, high in bicarbonate alkalinity, and bacteriologically unsatisfactory.

Copper sulphate was found unsuited to a water of the type used.

As much as 2 parts per million of available chlorine, administered as chloride of lime and at a single dose, failed to keep the bacterial content of the water within safe limits due to the rapid disappearance of available chlorine from the water. It was only with daily additions of chloride of lime that adequate purification resulted. With this procedure, however, it was found possible to keep a pool bacteriologically clean for two weeks without change of water. There were noted no objectional features arising from the large quantities of disinfectant added (daily additions of 0.5 part of available chlorine per million parts of water). The advantages of the periodic administration of hypochlorites in small quantities over the addition of the same total amount at a single dose are discussed.

The factors influencing chlorine consumption and the chlorine-binding power of various substances were studied. The temperature of the water and the amount of light a pool receives greatly influence the decomposition rate of hypochlorites. Body products have an especially great binding power for chlorine, a fact that emphasizes the need of great personal cleanliness among users of swimming pools.

Determinations of dissolved chlorides or of oxygen consumption give little or no indication of the purity of swimming-pool water. The tests that apparently give the most information are determinations of available chlorine and of chlorine-consuming capacity.

In the purification of the water of swimming pools each case should be considered as a separate problem, since the procedure adapted to one may be entirely unsuited to another. Chemical study is as necessary as bacteriological to obtain the best results. The minimum quantities of hypochlorites necessary to maintain an excess of available chlorine should first be established by experiment, and these quantities should be administered at short, regular intervals. Once the dosage proper for ordinary circumstances is known, it becomes an easy matter to keep a pool in sanitary condition.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Chart, showing the decomposition of calcium hypochlorite in water.
2. Chart, showing the relation between oxygen consumption and number of bathers.

NOTE ON THE TIDAL VARIATION OF SPRINGS AND DEEP WELLS IN THE PHILIPPINE ISLANDS[1]

By George W. Heise

(From the Laboratory of General, Inorganic, and Physical Chemistry, Bureau of Science, Manila, P. I.)

Throughout the Philippines there are many springs, located near the coast, whose flow is greatly affected by the tides. Some of them, situated on the beach, are completely covered at high tide, so that to get water from them one is obliged to wade into the ocean and catch the fresh water as it issues from the sands. Many drilled wells show a great tidal variation in quantity of water. For example, the well at Bauan, Batangas, 90 meters deep, flowing 190 liters per minute at low tide, has a flow five times as great (950 liters) at high tide. Some, as in the case of several located at Iloilo, flow at high tide, but must be pumped at low water.

With all this variation in quantity of water, there is very little, if any, change in quality. This is quite to be expected, since the natural flow of subsoil water is toward the sea, generally under pressure great enough to prevent the admixture of sea water. A number of flowing wells in Iloilo, which yield brackish waters in quantities varying greatly with the tides, showed no appreciable change in quality, and because of their peculiar composition (high chlorine content and absence of sulphates and occasionally of calcium salts), entrance of sea water was practically out of the question.

A spring at Punta Oslob, Cebu, was described by Abella,[2] as follows:

> It emerges and flows over the beach in the zone which is alternately submerged and uncovered by the tides, and its waters, which are salty when the mouth of the spring is not covered by the sea, are, on the other hand, perfectly sweet when it (the spring) is covered at high tide. In consequence the inhabitants who use this water for drinking, await high tide to fill their 'bambones' (bamboo tubes) or jars, holding them in the whirl or eddy which the sweet water produces in the supernatant sea water.

Abella offers the suggestion that there may exist a cavity in the rocky structure of the beach in which water collects at high tide, discharging into the spring and contaminating the water at low tide.

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[1] Received for publication December 6, 1915.

[2] Rápida descripción * * * de la isla de Cebú. Madrid (1886), 87.

Correspondence with the district health officer of Cebu concerning the present status of the spring elicited the following information:[3]

> The spring in question is located at a distance of about 1 km. from the town of Oslob. It is found on the seashore which is rocky (covered with broken up particles of rock, not gravel), and slopes gradually toward the sea in such a way that at low tide the water recedes some 200 feet from the spring. Two big rocks mark the outlets of two springs separated from each other by a distance of about 30 feet * * *. One of these is situated further up from the sea and has its outlet in hollowed ground close to a big rock. Its flow is constant only at high tide, discharging only a small amount of water, and it completely dries up at low tide. Only when sea water mixes with it does the water becomes fresh, but soon gives a salty taste at the return of the tide. * * * About 30 feet from the spring above described, and further toward the sea, is another spring which has its outlet beneath a big rock. This is a much larger spring than its neighbor, discharging a large volume at high and low tide. * * * Being situated at a lower level than the former spring, it is completely covered with sea water at high tide to a depth of about four feet. It is impossible to obtain fresh water at this time, because the water of the spring can not rise up to the surface * * *. On account of their identical behaviour, these two springs probably represent two outlets of one and the same spring. * * * The water of the spring constitutes drinking water for the town of Oslob for years beyond memory, * * *.

Samples were obtained and analyses were made to ascertain whether or not this spring, or series of springs, really gave brackish water at low tide and fresh water only at high tide as reported, with the following results:

Sample No.		Chlorine, parts per million.
1.	Small spring at low tide	15
2.	Small spring, covered by tide	110
3.	Large spring at low tide	620
4.	Large spring at low tide (duplicate of No. 3)	610
5.	Large spring, covered by tide	840
6.	Large spring, covered by tide (duplicate of No. 5)	730

The greater salt content of the spring waters at high tide may well be accounted for by the unavoidable admixture of sea water in samples secured from below the surface of the sea.

Regarding these samples, a further letter from Doctor Cruz states:[4]

> The small spring, a sample from which was requested at low tide, was closely observed. It was noted to disappear completely at low tide, as was stated in previous report. It was, therefore, impossible to obtain a sample from it as was requested. However, at the return of the tide and just as it reaches the large spring, but not the outlet of the small one,

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[3] Letter of the acting district physician, Dr. Adriano Cruz.

[4] June 17, 1915.

water begins to ooze out from the latter, and sample forwarded you is taken from this at this time. Evidently the water (small spring) is not brackish as was reported, and neither is it so when covered by the tide. I must admit that * * * unusual weight has been given to tradition, current in the town of Oslob * * *.

There is, then, no reason to believe that the springs at the present time are really fresh at high tide and brackish at low tide, as had previously been reported. Perhaps the character of the springs has changed in recent years; perhaps the erroneous idea that the two springs were different outlets for the same water caused people to believe that the character of the water changed with the tide. This latter explanation seems most reasonable in view of the fact that at low tide the only available water (samples 3 and 4, from large spring) was brackish, while at high tide, the only accessible source (small spring) yields fresh water (sample 2).

MANUFACTURE OF LIME IN THE PHILIPPINE ISLANDS *

By L. W. THURLOW

(From the Bureau of Science, Manila, P. I.)

TWO PLATES

The status of lime manufacture in the Philippine Islands has always been far from satisfactory. In many sections lime is made in considerable quantities, but both the raw materials and the kilns employed usually prohibit production of a really good substance. Lime is often made from sea shells that are poorly cleaned and, consequently, yield an impure product. The kilns are frequently simply holes in the ground in which the limestone and wood are placed. In general, such arrangements are very wasteful in fuel and labor and make the cost of production of an inferior lime higher than it should be for a good one under proper conditions. However, in some cases these processes are more highly developed; a forced draft is sometimes used, and a fair product is obtained. Lime manufactured by crude methods is often satisfactory for ordinary construction work, but it is not at all suitable for chemical purposes, such as sugar manufacture. Since 1912 the demand for a better grade of lime has been so insistent that much has been imported into the Philippine Islands at considerable expense.

The investigations of lime manufacture now under way in the Bureau of Science were undertaken to encourage the local lime industry by pointing out the best deposits of limestone and the type of kiln best suited for the economical production of the material. The first kiln was too small to give results entirely comparable with commercial practice and owing to lack of funds was too lightly constructed to be permanent; but it gave fair results after a careful study of the details of its operation had been made. The lime produced was so far superior to that heretofore obtained in commercial practice in the Philippine Islands that it has been decided to present this report and to announce that a new kiln of greater capacity and improved design is practically completed, and experimental work will soon be carried on.

THE BUREAU OF SCIENCE EXPERIMENTAL KILN

The first experimental kiln at the Bureau of Science is shown on Plate I. It was cylindrical in shape and was constructed of

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* Received for publication December 1, 1915.

fire brick and cement. The smokestack shown in the illustration had been replaced by one 8 meters high by 40 centimeters in diameter before the tests described in this paper were undertaken. Considerable lime of excellent quality was burned in 1913 and 1914. This lime was used in the experiments of the Bureau of Science in the preservation of nipa sap for commercial production of sugar,[1] and a considerable quantity was sold to private individuals and to the Bureau of Supply.

The operation of the kiln, during the first two years, was primarily to obtain sufficient lime for experiments along lines entirely separate from the lime industry itself. Consequently no accurate data concerning the process were kept. In January, 1915, I was directed to run a series of tests on the kiln to determine the capacity, the fuel consumption per unit weight of lime, and other factors. Although the quality of the output of the kiln was well known, no study had been made of the cost of operation, and it was desired to know whether or not the kiln represented as great an advance in economy as it did in excellence of product.

A common practice in this kiln was to use pieces of limestone ranging from 5 to 10 centimeters in diameter. Under these conditions the stack did not always insure sufficient draft. A No. 2 Sirocco suction fan, driven at the rate of 500 revolutions per minute, was installed and proved very satisfactory. In one day the kiln was heated to the proper temperature, and on January 15, 1915, an experimental run was commenced. The kiln was fired at regular intervals—about four shovelfuls of Fushun coal per hour were thrown in at each door. The draft was controlled by a valve in the suction pipe at the top of the kiln. The results of the three-day run are recorded in Table I.

TABLE I.—*Results obtained from first run of kiln.*[a]

Date.	Run.	Coal burned.	Lime produced.	Coal on lime.	Lime per kilo of coal.	Lime per hour.
1915.	*Hours.*	*Kilos.*	*Kilos.*	*Per cent.*	*Kilos.*	*Kilos.*
Jan. 15 to 16	12	190	293	64.8	1.54	26.8
Jan. 16 to 17	24	393	922	42.7	2.34	38.4
Jan. 17 to 18	15	331	645	51.3	1.96	43.0
Total	51	915	1,860			
Average				49.1	2.04	31.0

[a] The temperature of the flue gases was very high, probably from 400° to 500°.

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[1] See *This Journal, Sec. A* (1913), 8, 377.

The arrangement of the fan made it impossible properly to sample the flue gases on the first run, but this was corrected for the second run. The temperature of the kiln gases in a well-regulated kiln should not exceed 100°C. The temperature of the flue gases in our first run was much too high, and the loss from this cause represents at least 10 per cent of the coal consumed. In order to reduce this value, some changes were made in the kiln. To increase the efficiency of the preheating zone, the kiln was increased in height by 2.5 meters, and holes were made in one side of the kiln at intervals of 0.6 meter, from the grates to the top, so that, in case the kiln became clogged, iron bars could be inserted without interfering with the fire box.

The modified kiln is shown in Plate II. Because of the changes required in the kiln, and on account of other work, I was unable to continue the experiment for some time. On April 27 the kiln was charged for the second run. The charge consisted of 2,500 kilograms of rock, 10 centimeters in diameter. The results of this run are given in Table II.

TABLE II.—*Results obtained from second experimental run.*

Date.	Run.	Fuel burned.	Lime produced.	Coal or wood on lime.	Lime per kilo of coal.
1915.	*Hours.*	*Kilos.*	*Kilos.*	*Per cent.*	*Kilos.*
Apr. 28 to 29	24	[a]258	612	42.2	2.37
Apr. 29 to 30	([b])				
Apr. 30 to May 1	24	[a]464	1,086	42.7	2.34
May 1 to 2	24	[a]515	1,292	39.8	2.51
Total	72	1,237	2,990		
Average	24			41.3	2.42
May 2 to 3	24	[c]849	1,301	65.2	1.53

Date.	Lime per hour.	Gas analyses.			Temperature.
		Oxygen.	Carbon monoxide.	Carbon dioxide.	
1915.	*Kilos.*				*°C.*
Apr. 28 to 29	25.5	17.1	0.3	5.4	163
Apr. 29 to 30					
Apr. 30 to May 1	45.3	16.5	0.0	6.1	195
May 1 to 2	53.8	16.8	0.0	6.0	185
Total					
Average	41.5	16.8	0.1	5.7	181
May 2 to 3	54.3	19.8	0.0	1.1	204

[a] Coal.

[b] Kiln overdrawn—no lime.

[c] Wood used as fuel.

The second run was much more satisfactory. The temperature of the gas issuing from the stack was very greatly reduced with a corresponding decrease in the average coal consumption of 10.2 per cent. The average output of the kiln was increased to nearly 1 metric ton per twenty-four hours. The results of the gas analyses show an excess of air, admitted by the warped fire doors, which did a great deal to reduce the efficiency of the kiln. With properly fitted doors the coal consumption could easily be further reduced from 5 to 10 per cent.

Wood, consisting of thin strips of air-dried lumber and waste, was used on the last day of the second run. The amount of wood consumed is very small when it is considered that this wood has only about half the calorific value of coal. Wood is better adapted to lime burning than most coal, for it has a longer flame. The thermal conductivity of lime is very low, and the flame must surround the rock to give the best results. Where wood can be obtained, it is preferable, but in many places only coal is available. Information with regard to the value of Philippine firewood has been published by Cox.[2] The characteristics of some Philippine coals that are available for use in lime kilns are given by the same author.[3]

The kiln has served its purpose in demonstrating kiln requirements suitable for local lime burning and in forming the basis for the design of the new kiln.

[EDITOR'S NOTE.—Lime manufacture is more highly developed in some places in the Philippine Islands than the outline of processes in the first page of this report may indicate. For example, at Baguio large kilns are built of limestone and the fuel and rock are kept separate so there should be no contamination of the lime with ashes. The kilns require relining from time to time, because fire brick are not available. The kilns are not continuous, and there is considerable waste of fuel and labor.]

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[2] Ibid. (1911), 6, 1–22.

[3] Ibid. (1909), 4, 211–229, and (1912), 7, 1–17.

ILLUSTRATIONS

Plate I. First lime kiln built by the Bureau of Science.
Plate II. Second lime kiln built by the Bureau of Science.

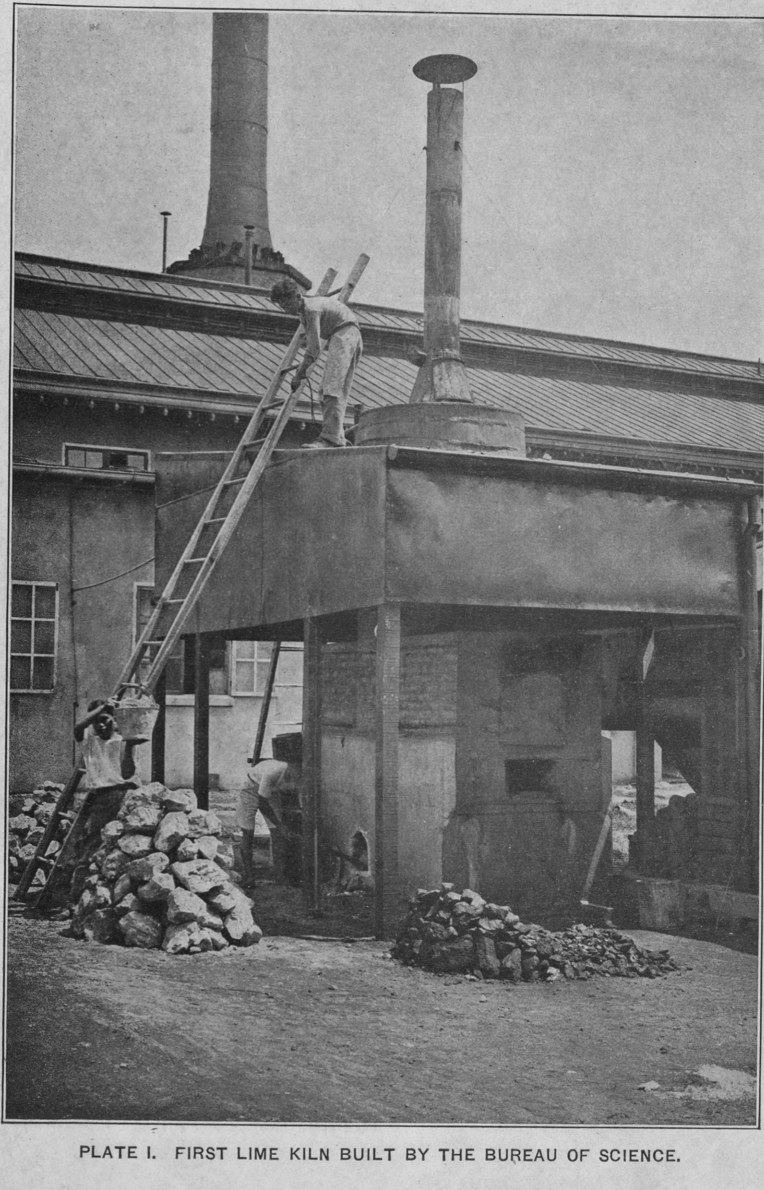

PLATE I. FIRST LIME KILN BUILT BY THE BUREAU OF SCIENCE.

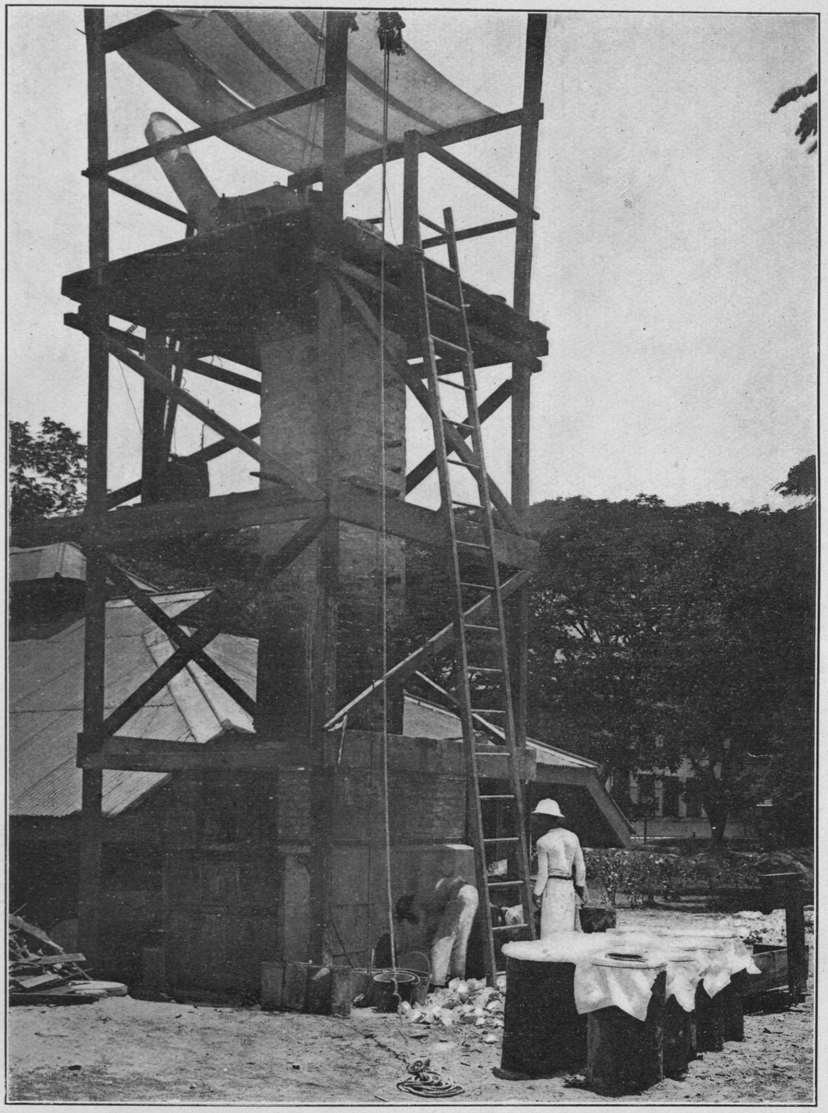

PLATE II. SECOND LIME KILN BUILT BY THE BUREAU OF SCIENCE.

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